Name _____ AP Chemistry

Le Chatelier's Principle Online Activity

The value of K is a constant at a particular temperature. The only factor that changes the value of the equilibrium constant is temperature. Pressure and changes in concentration will not affect the value of K. However, these factors will affect the position of the equilibrium (i.e. whether it favors the reactants or the products) along the temperature. Le Chatelier's proposed a theory that stated:

> *If a change is imposed on a system at equilibrium, the position of the equilibrium will shift in a direction that tends to reduce that change.*

In this activity you are going to learn how the system reacts to different factors and then apply it to different chemical reactions.

Part I

1) Go to the class website, click on "Unit VI—Kinetics & Equilibrium," and then go to the bottom of the page. Click on the first link under "Le Chatelier's Principle Online Activity."
2) Choose "Change in Concentration." This focuses on the reaction:

$$FeSCN^{2+}\ (aq) \leftrightarrow Fe^{3+}\ (aq) + SCN^{-}\ (aq)$$

3) Now choose 'Add NaSCN.' Wait a few minutes and record below what happens to the reaction (i.e. which way does the reaction shift):

4) Choose "Back." Now choose 'Remove Fe^{3+}." Wait a few minutes and record below what happens to the reaction (i.e. which way does the reaction shift):

5) Based on what you observed for steps #3 and 4, how will a reaction change with the addition or removal of a reactant or product?

6) Choose "Change in Pressure" at the bottom of the simulation. This focuses on the reaction:

$$I_2\ (g) \leftrightarrow 2\ I\ (g)$$

7) Choose ‘Increase Pressure.’ Wait a few minutes and record below what happens to the reaction (i.e. which way does the reaction shift):

8) Choose “Back” and then chose ‘Decrease Pressure.’ Wait a few minutes and record below what happens to the reaction (i.e. which way does the reaction shift):

9) Based on what you observed for steps #7 and 8, how will a reaction change with an increase or decrease in pressure and how does the total number of moles change with the shift?

10) Choose “Change in Temperature” at the bottom of the simulation. This focuses on the reaction:

$$N_2O_4\ (g) \leftrightarrow 2\ NO_2\ (g)$$

11) Choose ‘Increase Temperature.’ Wait a few minutes and record below what happens to the reaction (i.e. which way does the reaction shift). Is the reaction exothermic or endothermic?

12) Choose ‘Back’ and then choose ‘Decrease Temperature.’ Wait a few minutes and record below what happens to the reaction (i.e. which way does the reaction shift). Is the reaction exothermic or endothermic?

13) Based on what you observed for steps #11 and 12, how will a reaction change with an increase or decrease in temperature? How does the reaction being exothermic or endothermic affect how the reaction changes?

Using your answers for #5, 9, and 13, fill in the table below to create general rules for determining how a reaction will react to a change:

Change	Rule to Predict Reaction Movement
Addition or removal of reactant/product	
Increase or decrease pressure	
Increase or decrease in temperature	

Part II

1) Go back to the class website and click on the second link under "Le Chatelier's Principle Online Activity."
2) Click on "I. Cobalt System." The cobalt reaction changes color based on position of reaction (blue for reactants and red for the products):

$$CoCl_4^{2-}\ \{blue\} + 6\ H_2O \leftrightarrow Co(H_2O)_6^{2+}\ \{red\} + 4\ Cl^- + heat$$

3) Five icons surround the purple test tube (showing the initial equilibrium state): heat, ice water, addition of H_2O, addition of KCl, and addition of $AgNO_3$ (silver ions will react with the chlorine ions in the test tube to form a precipitate of AgCl). Click on each icon in turn, recording your observations in the table below. Circle which way the reaction shifted with the change in equilibrium and explain why this shift occurred using your rules from Part I:

Change	Observations	Reaction shifts to	Explanation
Increasing temperature		Left Right	
Decreasing temperature		Left Right	
Addition of H_2O		Left Right	
Addition of KCl		Left Right	
Addition of $AgNO_3$		Left Right	

4) Click the back button in the browser to return the starting page. Now click on "IV. Chromate system." The chromate system, like cobalt system, changes color from yellow to red based on the position of the reaction:

$$2\ CrO_4^{2-}\ \{yellow\} + 2\ H^+ \leftrightarrow Cr_2O_7^{2-}\ \{red\} + H_2O$$

5) There are two icons surrounding the orange test tube (showing the initial equilibrium state): addition of HCl and addition of NaOH (which reacts with $Cr_2O_7^{2-}$). Click on each icon in turn, recording your observations in the table below. Circle which way the reaction shifted with the change in equilibrium and explain why this shift occurred using your rules from Part I:

Change	**Observations**	**Reaction shifts to**	**Explanation**
Addition of HCl		Left Right	
Addition of NaOH		Left Right	

Practice Problems

1) Hemoglobin (Hb) and oxygen gas form a complex (HbO_2) that carries oxygen throughout the human body. Unfortunately, carbon monoxide also binds to hemoglobin so that equilibrium is established. Carbon monoxide poisoning occurs when the concentration of HbO_2 in the blood is reduced:

$$HbO_2 + CO \leftrightarrow HbCO + O_2$$

The first aid for a person suffering from carbon monoxide poisoning is to (1) remove them to an area of fresh air, and (2) administer oxygen. Using the principles of equilibrium, explain how each of these helps to restore the HbO2 concentration.

2) Consider the system

$$4\ NH_3\ (g) + 3\ O_2\ (g) \leftrightarrow 2\ N_2\ (g) + 6\ H_2O\ (l) \qquad \Delta H = -1530.4\ kJ$$

(a) How will the amount of ammonia at equilibrium be affect by
   (i) removing O_2 (g)?
   (ii) adding N_2 (g)?
   (iii) adding water?
   (iv) expanding the container at constant pressure?
   (v) increasing the temperature?

(b) Which of the above factors will increase the value of K? Which will decrease it?

3) Consider the system

$$SO_3\ (g) \leftrightarrow SO_2\ (g) + \tfrac{1}{2}\ O_2\ (g) \qquad \Delta H = 98.9\ kJ$$

(a) Predict whether the forward or reverse reaction will occur when the equilibrium is disturbed by
   (i) adding oxygen gas.
   (ii) compressing the system at constant temperature.
   (iii) adding argon gas.
   (iv) removing SO_2 (g).
   (v) decreasing the temperature.

(b) Which of the above factors will increase the value of K? Which will decrease it?